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QUESTIONS AND EXERCISES

TO BE USED IN CONNECTION WITH

OUTLINES OF PHYSICS

AN ELEMENTARY TEXT-BOOK

BY

EDWARD L. NICHOLS

PROFESSOR OF PHYSICS IN CORNELL UNIVERSITY

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A SET OF QUESTIONS AND EXERCISES TO BE USED IN CONNECTION WITH NICHOLS' OUTLINES OF PHYSICS

CHAPTER I

1. What advantage is gained by expressing fractions of a unit (of length, mass, or time) decimally instead of by means of a common fraction?

2. What is the mass, expressed in grams, of 1 cubic meter of water?

3. What is the mass (in grams) of a liter of water?

4. A how much longer distance is 100 meters than 100 yards? (Express your answer (1) in meters, (2) in centimeters, (3) in yards.)

5. If cloth were sold by the meter and the price per meter were the same as the price per yard, what would be the percentage of gain to the buyer?

6. The cyclometer of a bicycle records 1 mile for every 720 revolutions of the wheel. If it is to record kilometers, once in how many revolutions of the wheel must it be made to record? (Solve first by use of the approximate value of the mile given on p. 4. Then compute by use of Appendix I and find the error, in revolutions of the wheel, introduced by taking the approximate ratio.)

7. If in Fig. 4 (p. 6) the line *ab* be set to coincide with scale division 4, what will be the position of *cd* upon the scale?

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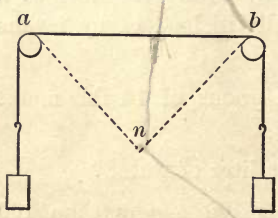
Is there anything to be gained by thus setting one of the lines to coincide with a scale division?

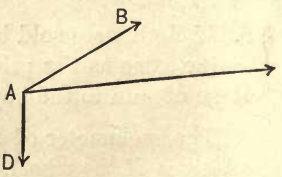
8. In Fig. 5 (p. 8) suppose the fine lines of the cross-section paper to be strictly equidistant. How many times more accurate would the determination of their distance in scale divisions be if made from a single observation of the lines a and h upon the scale, than though the distance of two neighboring lines were directly noted? How would you compute the distance in the former case?

CHAPTER II

9. At the ends of a wire or cord are suspended two equal weights, stretching it horizontally between the two pulleys a and b. A third weight equal in mass to each of the others is hung from the cord midway between a and b. In what position will the system come to rest? (See Arts. 12 and 13.)



10. If in the above example we add weights between the pulley until the angle n is 90°, what will be the relation of the weights at the end and at the middle of the cord?



11. Find graphically the resultant of the forces AB, AC, AD.

12. Find graphically two forces that are equivalent, when acting together upon the point A, to the force AB.

13. Can a cable or wire be stretched horizontally until it does not sag at all? Explain.

14. The string of a violin or guitar may be stretched upon the instrument almost to the breaking point, yet it can be readily displaced laterally by a touch of the finger. Why?

15. A weight hangs vertically by a wire from a point A. To the wire a string is attached by means of which a lateral pull is exerted. Show graphically the lateral pull for any given position; also the force upon the wire above the point of attachment.

16. In the above case, will the pull upon the string be greater when the latter is horizontal or when its direction bisects the angles between the upper and lower portions of the wire? Why?

17. An oarsman can propel a boat in still water with a speed of 3 m. per second. If he rows at that speed at right angles to the current of a stream which flows at the rate of 4 m. per second, how far from his starting point will he be in one minute? Give a diagram.

CHAPTER III

18. In Galileo's experiment (Art. 24), what must be the angle of the inclined plane to reduce the component force of gravity tending to produce motion to one-half?

19. A ball upon an inclined plane traverses a distance of 100 cm. from rest during one second. How far will it travel in 10 seconds? (See Art. 26.*)

20. Under the conditions of Question 19, what will be the velocity of the ball at the end of one second? of 10 seconds?

21. A body falling freely through space traverses a distance of 450 cm. in one second. What will be its velocity at the end of five seconds?

22. A ball dropped from a balloon reaches the earth in 10 seconds. The acceleration due to gravity is 980. cm.† What is the height of the balloon in meters?

* In this and all subsequent questions upon falling bodies, the resistance of the air is to be neglected.

† In subsequent questions, the acceleration due to gravity will be designated by the symbol g. Its value is to be taken as 980 cm. unless otherwise specified.

23. In a certain locality gravity produces an acceleration of 980 cm. What is the force of gravity in dynes upon a mass of 1000 g.?

24. A cannon ball weighs 10,000 g. If it takes $\frac{1}{1000}$ of a second to bring it to its full velocity at the muzzle of the gun when fired, and that velocity is 500 m. per second, what is the average force of the explosive in dynes?

25. At the surface of the moon, the acceleration due to gravity is $16\frac{1}{2}$ per cent of that at the surface of the earth. What is the force of gravity there upon a mass of 1 g.?

CHAPTER IV

26. From a point 122.5 m. above the surface of a lake, a gun is fired horizontally. The velocity of the bullet when it leaves the gun is 400 m. a second. At what distance measured along the water, from a point vertically below the gun, will the bullet strike the surface of the lake? (The value of g is 980 cm.)

27. How many seconds will elapse after the firing of the gun described in Question 26 before the bullet will strike the water? Draw a diagram showing its position at the end of each successive second.

28. Assuming the conditions of Questions 26 and 27, consider the gun to be pointed upwards at an angle of 30° with the horizon. Draw a diagram showing the course of the bullet. Repeat for angles of 45° and 60°. (See Art. 32.)

29. A bullet is shot vertically upwards. Neglecting the resistance of the air, how would its velocity, when under the influence of gravity it has returned again to the level of the gun, compare with its initial velocity? Explain.

30. A bullet is shot horizontally from the mouth of a gun, and another at the same instant is dropped vertically from the

same height above the ground. Show that if the ground is level they will reach it at the same instant of time. Give a diagram.

31. By means of a spring gun mounted vertically upon the deck of a moving vessel, a ball is thrown upwards. What kind of a curve will its path be?

CHAPTER V

32. If the length of a pendulum beating seconds in a certain locality be 99 cm., how long a pendulum would make a single oscillation in $\frac{1}{10}$ of a second; in one minute?

33. A clock with seconds pendulum keeps accurate time at sea level in latitude 45°. If moved to the equator without disturbing its adjustment, will it gain or lose and how much per day? (See Arts. 27 and 42.)

34. If such a clock be taken to a mountain top, will it gain or lose? Why? To restore it to its proper rate at the higher locality, must the pendulum be lengthened or shortened? Why?

35. The value of g on the surface of the moon is about 162 cm. How long must a pendulum be to beat seconds there?

36. Find graphically the relative motions of a pendulum bob during a single oscillation. [For this purpose draw a circle and its horizontal diameter. Divide the upper semicircumference into six equal parts. From the ends of these divisions drop perpendiculars upon the diameter. The intersections of these perpendiculars with the diameter will mark the successive positions of a bob, traveling along the diameter, after $\frac{1}{6}$, $\frac{2}{6}$, $\frac{3}{6}$, etc., of its single oscillation has been completed. See Art. 146.]

37. From the diagram made under Question 36 construct a sine curve characteristic of the motion of the pendulum.

Draw a base line, and divide it into equal parts. Each of these corresponds to $\frac{1}{6}$ of a single oscillation. Construct your curve by an application of Art. 47.

38. If in the experiment described in Art. 48 a smoked cylinder be substituted for the plate, and the former be revolved upon an axis parallel to the plane of oscillation of the pendulum, one revolution for each single oscillation, what will be the form of the tracing?

CHAPTER VII

39. If the bob of the pendulum shown in Fig. 52 weighs 1000 g., and the vertical distance bc is 10 cm., how much work, in ergs, must be done to lift the bob from a to b? [The force of gravity upon 1 g. of matter is 980 dynes.]

40. If the pendulum in Question 39 is released at b, what velocity will the bob require when it swings past the point a, and what will be its kinetic energy in ergs?

41. Show that when the pendulum in Question 39 has reached the end of its upward movement at c, it has gained an amount of potential energy equal to the kinetic energy which it possessed by virtue of its velocity at the point a.

42. A projectile weighs 2000 g. Its velocity is 1000 cm. per second. How much work will it do in coming to rest? If its energy could all be applied to lifting a kilogram weight against gravity, to what height would it be raised? Let $g = 980$ cm.

43. The work required to lift 10 kg. to a height of 10 m. against gravity is how many kilogram-meters? Where g is 980 cm., how many ergs is this equivalent to?

44. To how many ergs is a kilogram-meter equal on the surface of a planet where g is 100 cm.?

45. What would be the result in Experiment 11 of using a wire instead of the rope described under Section (3)? Why?

CHAPTER VIII

46. In Fig. 45 suppose P_1 to be 100 g. and P_2 (including the pulley) to be 200 g. If $g = 980$ cm., what will be the force upon the hook which sustains the cord c? What will be the force upon the screw which holds the pulley A?

47. If the pulley weight P_1 (as above) fall 1 m., what work will it perform?

48. In Fig. 47 what weight must be attached at b to give under the action of gravity the force indicated; *i.e.* 50,000 dynes?

49. Which class of lever is represented in the crowbar (used in prying), the crowbar (used in lifting), the plyers, the scissors, the nut cracker, the human arm (used in lifting)? Why do we find it difficult to lift even a moderate weight with the arm extended horizontally?

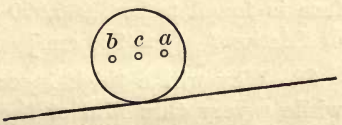
50. Under what circumstances is the wheel and axle preferable to a common lever with the same ratio of lever arms?

51. In Fig. 54 show that the work required to raise the ball from a to b along the plane is the same as that necessary to lift it vertically from c to b.

52. In what sort of equilibrium (stable, unstable, or indifferent) is a cone balanced upon its apex; a wedge balanced upon its edge; a cylinder resting upon a plane; a ball resting upon a plane; a cylinder suspended by means of a support through its axis; a stool with three legs on the floor; a stool with two legs on the floor?

53. How would you find the center of mass of a horseshoe?

54. Given a disk placed upon an inclined plane. If its center of mass is at a, what will it do if released? If at b? If at c?



55. In a balance if the milled nut above the axis of support at O (Fig. 64) be raised, what will be the effect upon the sensitiveness? What will be the effect upon the rapidity of movement of the balance? Why? If the nut be raised too high, *e.g.* until the center of mass is above the axis of support, what will be the result?

56. The arms of a balance differ in length by one part in a thousand. A body placed at the end of the longer arm just balances a kilogram weight placed at the end of the shorter. What is its correct weight? (Solve by applying the principle of moments; Art. 62.)

CHAPTER X

57. If in Experiment 16 a disk of wood, slate, or porcelain be substituted for the glass, what would be the effect upon the result of the experiment?

58. To measure the attractive force between water and a solid by the method of Experiment 16, what sort of substance would have to be chosen for the surface of the disk?

59. With the apparatus in Fig. 69 we find the weight m_1, which the weight m_2 is just capable of maintaining in uniform motion upon the plane, to be six times as great as m. What is the coefficient of sliding friction?

60. With the apparatus in Fig. 70 we find by increasing the pitch of the plane very carefully that the weights *begin* to slip when the angle is such that $\overline{AC}$ (Fig. 71) is four times $\overline{BC}$. What is the coefficient of starting friction?

61. The force necessary to move 10 kg. along a level surface is found to be 1,960,000 dynes. What is the coefficient of friction? [$g = 980$ cm.]

62. Why will a thick layer of a liquid act as a lubricant while a very thin film of the same liquid will hold the surfaces, between which it lies, as if cemented?

CHAPTER XI

63. Which possesses more nearly perfect elasticity of form, lead or steel? Dry wood or unseasoned wood?

64. A wire is 100 cm. long and 0.5 cm. in diameter. When stretched by the application of 10,000,000 dynes it increases in length 0.5 cm. What is the value of the stretch modulus? (See Art. 91.)

65. Two wires are of the same length and same diameter. Both are placed under equal stress. One stretches twice as much as the other. What is the relation between the stretch moduli?

66. A certain force suffices to stretch a wire of 0.1 cm. diameter so as to produce an elongation of 1 cm. What force will produce the same elongation in a wire of the same length and same material but 1.0 cm. in diameter?

67. Two rods are 2 cm. and 4 cm., respectively, in diameter, and of equal length. One end of each is rigidly clamped and forces are applied at the free ends to twist the bars. Compare the moments of the forces which will twist the two bars equally.

68. Along the surface of a rod a white longitudinal line is drawn with chalk. One end of the rod is clamped, and the other is twisted through an angle of 180°. What will be the position of the chalk mark upon the twisted rod midway from the clamped end to the twisted end? One quarter way from the clamped end?

CHAPTER XII

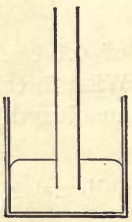
69. The principal force acting upon a vessel of liquid, at rest upon the surface of the earth, is that of gravity. From the position assumed by the surface of the liquid, what must we conclude concerning the direction in which gravity acts?

70. In Experiment 23, after the pressure applied at the funnel has been removed, will the air within the indicator bulb return precisely to its former volume? (See Art. 88.)

71. In Fig. 86 if the diameter of the piston A is 20 cm. and that of a is 1 cm., how far must a be lowered to raise A 1 cm.? Friction being neglected, what weight on A will 1 kg. on a sustain?

72. Show that in the case of the hydraulic press, where a large weight is raised, the whole equivalent of work must always be performed.

73. Into a glass jar containing mercury a glass tube open at both ends is plunged. If water be poured into the jar, will the mercury rise within the tube? If so, how high? (The density of mercury is 13.6 times that of water.) If water be poured into the tube instead of into the jar, what will the result be?



74. In Experiment 24, what will be the result if a large vessel such as a tub were substituted for the jar?

75. In Experiment 24, what will be the result of substituting an oil of three-fourths the density of water in the jar?

76. In Experiment 24, what would be the result of using mercury instead of water in the U-shaped tube?

77. A water-tight cask is strong enough to sustain an outward pressure of 5000 g. on each square centimeter of its surface. A long vertical tube, 1 sq. cm. in cross-section, is fitted to the head of the cask. The cask having been filled with water, we continue to pour water into the tube until the cask bursts. How high a column of water is required?

78. In the above question, what would be the height of the column provided the diameter of the tube were 10 cm.? Explain.

79. A body submerged in water loses one-half its weight. What is its density? (Express the density as defined in Art. 107, *i.e.* in grams per cubic centimeter of volume.)

80. A block of wood floats three-fourths submerged in water. What is its density?

81. The block mentioned in Question 80 floats entirely submerged in a certain oil. What is the density of the oil?

82. The density of ice is 0.917; that of sea water, 1.026. What proportion of a floating iceberg is submerged?

83. A metal ball weighs 100 g. We suspend it by a string and dip it in the water of a beaker which is placed upon the scale pan of a balance. When the ball is submerged without touching the bottom of the beaker, the latter is found to gain 20 g. in weight. What is the density of the ball? (See Art. 104.)

84. In the cylinder and bucket experiment (Art. 103) we fill the bucket with alcohol instead of water. Equilibrium is reached with the cylinder $\frac{8}{10}$ submerged in water. Find the density of the alcohol.

CHAPTER XIII

85. In Experiment 27 an aluminum ball is used. It weighs 100 g. in air, and its density is 2.6. What will it weigh in water?

86. A metal ball weighs 1000 g. It is suspended by a wire and carefully lowered into a cylindrical vessel of water. When the ball is fully submerged, the rise in the level of the liquid in the cylinder is noted and the diameter of the latter is measured. Show how from these observations the density of the ball may be computed.

87. Why are hydrometers (as shown in Fig. 99) constructed with long and narrow necks?

88. A Fahrenheit hydrometer weighs 50 g. When floating in water 20 g. must be added to submerge it to the mark upon the neck. In a solution of brine 30 g. are necessary to submerge it to the same point, while in an oil but 10 g. are required upon the scale pan. What are the specific gravities of the brine and of the oil?

89. In Experiment 28 a piece of glass weighing 10 g. is placed upon the upper pan of the hydrometer. The addition of 9 g. brings the pointer to the surface of the liquid. When the glass, the density of which is 2.7, is placed upon the lower pan, what weight must be placed upon the upper pan to submerge the hydrometer to the proper point again?

90. A certain specific gravity flask will hold 100 cc. of water. After pouring into it 100 g. of sand it is found possible to add 66 g. of water. What is the density of the sand?

91. Which of the elements mentioned in the table in Art. 114 would sink if thrown into mercury? Which would float upon water?

CHAPTER XIV

92. Draw a picture, showing the form which a drop of water, when inclosed in a glass tube of narrow bore, would assume. Indicate particularly the form of the surface film, applying the statements concerning the properties of the film given in Chapter XIV. Verify your drawing by observations upon water in a tube of about 1 mm. diameter.

93. Make a drawing as in Question 90, assuming the liquid to be mercury instead of water.

94. A tube of small bore with both ends open is dipped vertically into water and then withdrawn. A considerable quantity of water will remain in the vertical open tube in spite of the attraction of gravity. Why? Illustrate your answer by a diagram and verify by observations.

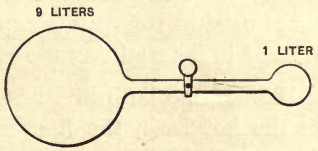
95. Why does the liquid rise higher in tubes of small bore than in tubes of large bore?

96. If the smaller tube in Fig. 109 were cut off below the level of the liquid within the tube, would there be an overflow at the open end? Explain.

97. In the case of glass dipped into water, is the angle of contact greater or less than 90°?

Each member of the class should be provided with a piece of glass tubing about 10 cm. long and 1 or 2 mm. in diameter, with which to test his answers to the questions upon this chapter.

98. Two connecting glass vessels hold respectively 1 l. and 9 l. The smaller contains a gas under a pressure of 1000 g. per square centimeter of surface. It is prevented from passing into the larger vessel, which is empty, by a stopcock. If the stopcock is opened, what will be the pressure after the gas has filled both vessels?



99. If in Torricelli's experiment water were used instead of mercury, how long a tube would be required?

100. Upon a mountain peak the barometer reads 38 cm. If a liter flask be filled with air at the level of the sea, carried to the peak and there opened, how much air will escape? What will the air which remains within the flask weigh? (Consult the table in Art. 124.)

101. What is the mass of a column of mercury 1 cm. in cross-section and 76 cm. high? From your answer deduce the pressure in grams per square centimeter, also in dynes per square centimeter, to which all surfaces which are exposed to the atmosphere at the level of the sea are subject. Reduce your answer likewise to pounds per square inch.

102. Suppose the upper end of the tube in Fig. 125 to be sealed, and pressure to be applied at h until the air inclosed above h is reduced to $\frac{1}{100}$ of its initial volume. What pressure

will be required (1) in atmospheres, (2) in grams, per square centimeter?

CHAPTER XVI

103. The expansion of copper when heated is much greater than that of platinum. If a strip of copper be soldered back to back with a strip of platinum and the double strip thus formed be heated, what will happen?

104. If a glass bulb be entirely filled with mercury and closed, what will happen on heating it? Why?

105. Does the change due to heating in the diameter of the tubes used in Regnault's experiment (Art. 134) need to be considered in determining the expansion of the liquid? Explain.

106. If the bulb in Fig. 134 be cooled and suddenly placed in the hot bath, the first movement of the mercury will be downward. Why?

107. In the Fahrenheit thermometers commonly used for household purposes, the ice point is at 32° and the melting point at 212°. One degree centigrade equals how many degrees Fahrenheit? (Express the ratio as a common fraction.)

108. When the Fahrenheit thermometer reads 90°, what is the temperature in degrees centigrade? (See Question 107.)

109. When the Fahrenheit thermometer indicates ten degrees below zero, what is the centigrade reading?

110. The temperature $+50°$ C. (centigrade) corresponds to what point on the absolute scale? (See Art. 140.)

111. A volume of gas at 0° C. is 1 l.; at what temperature will it expand to 2 l. if the pressure be maintained constant?

112. A liter of gas at 0° C. is heated to 100° C. How much must the pressure be increased to restore it to its original volume?

CHAPTER XVII

113. Why are the temperatures of the hot and cold water in Experiment 37 taken equally above and below that of the room?

114. If 10 g. of water at 50° C. be mixed with 100 g. of water at 10° C., what will the final temperature be?

115. If 100 g. of water at 50° C. be mixed with 100 g. of another liquid (not water) at 10°, and the final temperature be 40°, what is the thermal capacity of the liquid compared with that of water?

116. How much mercury, heated to 100° C., must be mixed with 1 kg. of water at 0° to make the temperature of the mixture 10°? (For specific heat of mercury see table in Art. 150.)

117. Three kilograms of lead are heated to 100° and are plunged into 1 kg. of water at 20° C. They produce a rise of temperature to 27°. What is the specific heat of the lead?

118. A quantity of boiling water is poured into the cavity of an ice-block calorimeter. It melts 200 g. of ice. What is the mass of the hot water? (See Art. 151.)

119. A block of copper weighing 1 kg. is heated to 100° C. It is then placed in a cavity in an ice block. How much ice will it melt?

120. How does the amount of heat energy necessary to evaporate a kilogram of water at 100° C. compare with that required to raise that amount of water from the melting point of ice to 100° C.?

121. In Experiment 41, if the lamp under the flask were extinguished and the apparatus were allowed to cool without removing the delivery tube from the beaker of water (Fig. 147), what would take place? Explain.

CHAPTER XVIII

122. In what respect does paraffin differ from water in the phenomena of fusion? (See Experiment 42.)

123. A massive steel cylinder is bored and fitted with a screw. The interior is filled with ice at 0° C. The screw is then turned so as to increase the pressure. What is the result? (See Art. 160.) If the pressure is 1000 atmospheres, at what temperature will the water freeze within the cylinder?

124. Describe the process of boiling.

125. Why in Experiment 43 will boiling cease when the stream of cold water is turned off?

126. What cools the water described in Art. 163 to the freezing point? (See Art. 165.)

127. Why does a moistened hand feel cool? Why cooler in the wind? Why much colder if moistened with ether than with water?

128. Why does the liquid described in Art. 166 assume the form of a spheroid? (Refer back to Chapter XIV.)

129. From the phenomena described in Arts. 166 and 167, what inference may be drawn concerning the proper explanation of the experiment, sometimes tried with success, of walking barefoot on red-hot metal without burning the previously moistened feet?

CHAPTER XIX

130. What is the source of the heat energy developed in Experiment 47?

131. What becomes of the energy expended to compress the gas in Experiment 48?

132. A mass of iron weighing 1000 kg. is transported to a height of 100 m. What work, in ergs, is expended? If

allowed to fall freely through the same distance, how many calories would be developed by the expenditure of all the energy of its fall?

133. A locomotive engine weighing 100,000 kg. is derailed and plunges into an embankment. If the entire energy of its motion, the velocity of which was 2600 cm. per second, were converted into heat, how much ice would it melt?

134. A kilogram of water falls 4000 cm. If all the energy thus developed were converted into heat, how many degrees would it warm the water?

CHAPTER XX

135. When the glass stopper of a bottle sticks fast, it can often be removed by warming the neck of the bottle. Why?

136. In Experiment 50, why must the heat be applied at the top of the vessel of water? (Consult Art. 179.)

137. If a printed page is held in the focus of a "burning glass," the ink-covered portions will be burned away, leaving the white surfaces unscorched. Why?

138. If a piece of black paper be laid upon the surface of ice, the ice under it will be found to melt more rapidly than elsewhere. Why?

139. If with a thermopile arranged between two blocks of clear ice, as in Fig. 171, we hold a glass flame in front of one of the blocks, there will be immediate indication that the face of the thermopile on that side is warmed. By which of the three processes mentioned in Art. 175 is the heat transmitted?

CHAPTER XXI

140. If in Experiment 60, Section *d*, while the vulcanite rod is still held near the plate of the electroscope, an electrified glass rod be likewise brought near, will the gold leaves diverge further, or will they come together? Why?

141. Why are gold leaves used in the electroscope rather than strips of any other metal?

142. An electroscope has been charged positively by contact with an electrified glass rod. Describe and explain in terms of the theory of two fluids what occurs when an electrified vulcanite rod is brought near.

143. An electroscope is given a permanent charge by induction from a positively electrified glass rod. Describe and explain what occurs when the same rod is subsequently brought near.

CHAPTER XXII

144. Contrast what is called the conduction of electricity (Experiment 61) with the transmission of heat by conduction (Experiments 49, etc.), as regards promptness of effect.

145. Should the containing vessel of an electroscope and the materials which support the rod and leaves be conductors or non-conductors of electricity? Why?

146. In Art. 202 it is stated that all kinds of matter are capable of electrification. Why, then, will a metal rod held in the hand and rubbed fail to show a charge? What precaution must be taken to make it do so?

147. Is glass when rubbed always positively electrified? (See Art. 202.)

148. From an inspection of Faraday's electrostatic series, what should you expect if you were to rub fur and glass together? What if you were to rub sulphur with fur?

149. Does Faraday's series throw any light upon the choice of sodium amalgam rather than silk as a rubber in the "plate" electrical machine?

150. If in an electrophorus we substitute glass for the vulcanite plate and excite with silk, what kind of a charge will be obtained on the metal plate after the usual operations have been performed?

CHAPTER XXIII

151. Why would not silk serve as well as linen in the construction of a Faraday bag? (Art. 210.)

152. Two small equally charged spheres are 1 m. apart. They repel each other with a force of 1 dyne. (Electrical action in such a case is inversely as the square of the distance.) What number of units of electricity are there on each?

153. In Experiment 65, why does not the charge continue to reside upon the entire surface of the curtain when rolled?

154. Why is a silk thread used in Experiment 65? Could such a thread be substituted for the fine wire which connects the curtain with the proof plane? Would a linen thread serve in the latter case? Explain.

155. How does the electrometer become charged in Experiment 65?

156. A metal sphere is brought near to a large conductor which is charged negatively. Show by a diagram the distribution of the induced charge upon the sphere.

157. The metal sphere after being connected for a moment with the earth is insulated and removed to a distance from the charged conductor. What is then its electrical condition? How would you test its condition?

CHAPTER XXIV

158. Why are not the tinfoil coatings of the Leyden jar continued to the top of the jar?

159. Given two Leyden jars of the same size and kind of glass. The glass of one of the jars, however, is twice as thick as that of the other. Which will have the greater capacity?

160. Given two condensers, each consisting of a pair of brass plates like those of the air condenser (Fig. 209). Be-

tween the plates are placed respectively a layer of paraffin, and a sheet of glass of the same thickness. Which condenser will have the greater capacity?

161. A Leyden jar is placed upon a sheet of hard rubber, thus insulating the outer coating. The knob is connected by means of a wire to the plate of an electroscope. The jar is charged until a considerable divergence of the leaves occurs. The outer coating is then connected with the earth. What will be the effect upon the divergence? Explain.

162. In Fig. 215, suppose the needle to be charged positively and the quadrants *aa* to be charged positively. Describe the movement of the needle.

CHAPTER XXV

163. Define the term "disruptive discharge." Is lightning such a discharge?

164. Describe the effect of reducing the pressure of the atmosphere through which a disruptive discharge takes place.

165. Explain the action of the revolving mirror. (Art. 229.)

166. In what respect does a Geissler tube differ from the vacuum tubes used for the generation of the X-rays?

CHAPTER XXVI

167. How may the difference of potential between the metals of a voltaic cell be shown to exist?

168. What is the difference between an open-circuit cell, and a closed-circuit cell?

169. What is the object of amalgamating the zinc of a voltaic cell?

170. What are the results of the accumulation of gas upon the metals of a voltaic cell?

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CHAPTER XXVII

171. Account for the difference in the appearance of the magnetic fields in Figs. 236 and 237.

172. Define the term "magnetic pole."

173. If the current in Fig. 239 flow counter-clockwise, and a needle be inserted in the coil, with point towards the observer, what sort of a pole will be formed at the eye end of the needle? When floating on water, which end will tend to point north?

174. Why is it always unlike poles which tend to come together in the experiment described in Art. 240 (*g*)?

175. Can a magnet be constructed without iron? If so, how?

176. In what position would the pull upon the magnet needle (depicted in Fig. 243) due to the earth's field be greatest? In what position would the pull due to the current be greatest?

177. A horizontal wire is stretched in a north-south direction. A current is sent through it from north to south. A floating magnet needle is placed under the wire. What position will the needle take?

CHAPTER XXVIII

178. Considering the earth to be a magnet, what sort of a pole is its north pole? (Like or unlike the north-seeking pole of a compass needle?)

179. In a position near the equator, what position would a dipping needle assume? In what localities would the needle become vertical?

180. The iron masts of ships are usually magnetized by the earth's field, the repeated shocks due to waves facilitating

the effect. Locate the poles (*a*) when the ship has been plying in northern waters; (*b*) in the southern hemisphere.

181. The iron pipes used in driving wells often become magnetized. Which pole (north-seeking or south-seeking) would be found at the top of such a pipe? Explain its occurrence.

182. An umbrella with steel ribs, which has been long in use, will be found to be a magnet. Which pole would you expect to find nearest the handle? Why? Verify your result by experiment.

183. The steel parts of a watch are partially protected from magnetization by using a case of iron or nickel. Upon what property of those metals does their protecting power depend?

184. Why are the pole pieces of the electromagnet depicted in Fig. 253 cut in the form of wedges?

185. If two similar horseshoe magnets are placed opposite one another, the north-seeking pole of the one in contact with the south-seeking pole of the other, they will attract each other strongly. Trace the course of the lines of force in such a case.

186. Around an iron ring a wire is coiled. If a current be sent through the wire, will the iron be magnetized? Will there be poles? Explain your answer.

CHAPTER XXIX

187. Indicate by a diagram the direction in which the electric current must circulate in the coils around the two needles in Fig. 257 in order that both may tend to turn in the same direction.

188. In a given circuit, the total resistance of which is maintained constant, the electromotive force is increased tenfold. What will be the effect upon the current? Why?

189. In a given circuit the electromotive force remains constant and the resistance is doubled. What is the effect upon the current?

190. In a given circuit we double both electromotive force and resistance. What is the effect upon the current?

191. In Experiment 80 suppose *ab* to be of copper, *bc* of iron, and *cd* of platinum. If the diameters are as 1 : 2 : 3 respectively, what deflections will be obtained? (See table in Art. 263.)

192. What is the resistance, in ohms, of a copper wire 1 m. long and 1 sq. mm. in cross-section? (Compute from Arts. 262 and 263.)

193. In the Wheatstone bridge (Fig. 264), if $ab = 10$ ohms, $bc = 50$ ohms, and $ad = 50$ ohms, what resistance must be given to the arm *dc* in order to bring the galvanometer to zero deflection?

CHAPTER XXX

194. Why is the copper wire in Experiment 85 (*c*) heated less strongly than the platinum wire?

195. Given 1 m. of iron wire and the same length of German silver wire. The diameters of the two wires are the same. If traversed by the same current, which will develop the greater amount of heat and in what proportion?

196. For electrical cooking, etc., the heat is usually derived from wires or strips of metal heated by a current. What metals are best adapted for such a purpose, and why?

197. The current is always sent through an arc lamp from the upper into the lower carbon pencil. Why?

CHAPTER XXXI

198. Is mercury an electrolyte? Explain your answer.

199. Draw a diagram similar to Fig. 275. Suppose the current to pass through the cell from left to right. Indicate by labeling the *kation* and *anion;* also what ion would be set free at each in the decomposition of Na_2SO_4.

200. In Fig. 279, twice as much gas is shown to have been generated in the left-hand as the right-hand tube. Which way did the current flow to produce this result? (The liquid in the voltameter is supposed to be water.)

201. One ampere of current is sent for one hour through (1) a water voltameter, (2) a copper voltameter, (3) a silver voltameter. How many cubic centimeters of hydrogen will be set free, and how many grams each of copper and silver?

CHAPTER XXXII

202. In an apparatus like that shown in Fig. 281, antimony forms the central bar with bismuth at either end. The thermo-electric current flows from left to right; which is the hotter of the two junctions?

203. At ordinary temperatures, which would furnish the higher electromotive force, a thermo-element of German silver — platinum, or of German silver — iron?

204. A thermo-element consists of a piece of platinum wire attached at each end to silver wires. A current is sent through the circuit from a battery. Both junctions are surrounded with ice. At which junction will the most ice be melted? Why?

CHAPTER XXXIII

205. In Fig. 284, suppose we are looking downward upon the field. If a wire represented by the black cross line be moved upwards through the field, what will be the direction of the current induced in the wire? Show by means of diagram, giving the lines of force.

206. A current is sent through the wire in Fig. 284. The force acting upon the wire in consequence is upwards. In which direction does the current flow?

207. A current is sent through a long cylindrical spiral spring. Will the spring tend to lengthen or contract in consequence? Answer by referring to action of lines of force; give diagram.

208. If the upper pole of the magnet in Fig. 291 is north-seeking, what must be the direction of the current in the attracted wire?

209. Find the direction of the induced currents in the loop of wire represented in Fig. 294.

210. A thunder cloud has a positive charge. This when discharged produces a flash of lightning between the cloud and earth. Surges of current are thus induced in a vertical iron pole. What will be their directions?

211. Mention and explain three methods of producing an induced current in a wire.

CHAPTER XXXIV

212. The flash of a firearm is seen five seconds before the report is heard. What is the distance of the observer from the gun? The temperature of the air is 20° C.

213. Suppose in Question 212 the wind to have been blowing towards the observer at a rate of 20 km. an hour. How much sooner did he hear the report than though it had been blowing in the opposite direction with that velocity?

214. During an Arctic winter Lieutenant Greely observed the velocity of sound to be as small as 305.6 m. per second. To what was this low value ascribable?

215. An observer is situated 991 m. from a cliff. How many syllables can he speak, at the rate of two per second, before the echo reaches him? The temperature of the air is 0° C.

CHAPTER XXXV

216. A locomotive whistle has a pitch of 256 vibrations per second. If sounded from a train coming towards the observer at a speed of 100 km. an hour, will its pitch be raised or lowered by the motion? How much?

217. When a bell is vibrating in the manner described in Art. 312 (Fig. 315), how many vibrating segments are there? Describe the position of the nodal lines.

218. What influence do the finger tips placed upon the edge of a vibrating plate, as for example in Fig. 313, have upon the arrangement of segments and of nodal lines?

219. Of the classes of instruments given in Art. 308, which is the least musical, and why?

CHAPTER XXXVI

220. Into how many segments is a tuning fork, which vibrates in its simplest manner, divided?

221. In Fig. 318, how many single vibrations of the tuning fork must correspond to each revolution of the disk, in order that the fork, when viewed through the slots, shall appear fixed in a given position?

222. The tracing of which Fig. 322 is a full-size reproduction, was made with a fork which performed 256 single vibrations per second. At what speed was the plate drawn? (Measure the curve with a rule divided to millimeters and compute.)

223. If the tracing shown in Fig. 324 were made with a pair of forks, the higher of which had a pitch of 100 single vibrations, how many beats (approximately) would be produced each second?

CHAPTER XXXVII

224. A weight of 1000 g. stretches a certain string so that it vibrates 100 times a second. If 2000 g. be applied, what will the pitch be?

225. A certain string, 1 m. long, vibrates 512 times a second. If its length is reduced to 250 cm., what will the pitch be?

226. A force of 1,000,000 dynes suffices to give a certain wire a pitch of 100 vibrations per second. The diameter of the wire is 0.02 cm. What tension (in dynes) must be applied to give the same pitch to a wire of the same material and same length, but the diameter of which is 0.1 cm.?

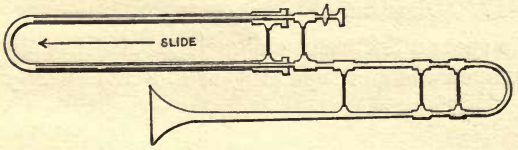
227. Two strings of the same material are mounted side by side upon a sonometer. One is stretched by means of a key until its pitch is 512 S. V. The other is stretched by weights to the same pitch. The weight required is 5000 g. The length of the latter string is twice as great and its cross-section double that of the string stretched with the key. Find the force in dynes applied by means of the key.

CHAPTER XXXVIII

228. How long an air column will be in resonance with a fork which has a pitch of 640 single vibrations per second? (See Art. 327.)

229. In the resonator depicted in Fig. 333, in which direction must the sliding part be moved to make the resonator respond to tones of higher pitch? Why?

230. In a "slide" trombone what is the effect upon the pitch when the slide is drawn out? Explain.



231. A performer will cause a trombone to utter several notes differing in pitch without moving the slide. How is this done?

CHAPTER XXXIX

232. What evidence is there that light is transmitted by some medium other than the air; an imponderable medium filling all space?

233. Light from a fixed star requires three years to reach the earth. What is the distance of the star (in kilometers and in miles)?

234. Light falls upon a plane mirror as in Fig. 342. If we turn the mirror through an angle of 15°, by how large an angle will the path of the reflected ray be changed? Why?

235. Draw a diagram similar to Fig. 344, and add lines showing the regions within which the image of the candle would be visible and those from which it could not be seen.

236. In Fig. 345 suppose the source of light a to be moved upwards from the axis of the mirror. Show by a diagram the displacement of b caused by a given movement of a.

237. Would a thermometer placed with its bulb in the *real* image of the candle (Fig. 347) tend to rise in temperature? Explain. Extend your reasoning to the case of a virtual image.

238. Objects always appear in the direction from which the light which enters the eye from them comes. Apply this to the bent appearance of a stick thrust obliquely into water. Give a diagram.

239. A diver submerged beneath still water looks obliquely towards the sun. Will its altitude appear less or greater than it really is? (Diagram.)

240. To spear a fish, seen obliquely from above the surface of a lake, must one aim beyond it, or in a more nearly vertical direction? (Diagram.)

241. Construct a diagram showing by lines the region from which looking upward towards the surface of a glass of water the surface would seem to be opaque.

CHAPTER XL

242. If we disperse the light from a gas flame, or candle flame, and obtain its spectrum, to which of the classes in Art. 352 should we expect it to belong? Why?

243. To which class does the spectrum of the crater of the electric arc belong? To which class the spectrum of the arc itself? (See Art. 273.)

244. Draw a diagram showing how you would arrange the apparatus for Experiment 112.

245. Why do the absorption spectra of gases show *black lines*, while in passing light through solids and liquids whole regions of the spectrum are cut away by absorption?

CHAPTER XLI

246. Where must the source of light be in order that a "converging" lens may cause the rays after passage to *diverge?* Give diagram.

247. Draw diagrams of two lenses, each of which has one convex and one concave face (concavo-convex lenses). One of these lenses is to be convergent; the other divergent.

248. In order that image and object may be of the same size, what must be their relative distances from the lens?

249. Since lenses of small aperture give as large images as lenses of great aperture, why is trouble and expense taken to produce astronomical telescopes of enormous aperture?

250. A certain telescope magnifies 200 diameters. How many times would the apparent area of a body like the moon be increased by means of it? How far away would the moon seem to be when viewed through such an instrument?

251. What is the difference between *spherical* and *chromatic* aberration? How may each be counteracted?

CHAPTER XLII

252. Suppose the two rays of polarized light that emerge from a doubly refracting prism (Fig. 378) to be viewed through a Nicol prism. Describe the phenomena.

253. A bit of mica placed between "crossed" Nicol prisms restores light to the field of view. Describe what takes place.

254. In Experiment 121, why do colors first show themselves at the top of the film, and why do they tend to arrange themselves in horizontal bands?

CHAPTER XLIII

255. What purpose do the humors of the eye serve?

256. In a certain eye the image of objects at a considerable distance falls *behind* the retina. Is the eye near or far sighted, and what must be the kind of spectacle lens to aid vision?

257. An eye lacks all power of accommodation. Objects at middle distance are in focus, but not very near nor very distant objects. What kind of spectacles would aid in reading, and what kind would improve distant vision?

258. Name as many cases as you can of colors produced by interference.

259. Why is it difficult to distinguish bluish greens from greenish blues by candle light? Why cannot colors be distinguished at all by sodium light?

260. Of what does the spectrum consist to a red-blind person? to a green-blind person? (Consult Arts. 287, 388, 389.)

261. How are contrast effects produced?

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